APPARATUS AND METHOD FOR MACRO FINANCIAL RISK ANALYSIS AND PROCESSES

BACKGROUND OF THE INVENTION

The invention relates generally to the processing of financial and economic data. More particularly, this invention relates to a technique for modeling risk between entities and sectors in an economy.

Recent crises have highlighted the need for new tools to evaluate price, credit, and liquidity risk in economies, as evidenced by the deficiency of early warning/surveillance systems and subsequent large losses incurred by lenders and investors in recent crises.

Investors, creditors, academics and policy makers have underlined the need for improved analysis of risks in economies. In 1999, Alan Greenspan stated, "our analytical tools are going to have to increasingly focus on changes in asset values and resulting balance sheet variations if we are going to understand these important economic forces." In a 1998 paper (The Asian Currency Crisis: What happened and what comes next) Rudiger Dornbusch stated, "The right answer for crisis avoidance is controlling risk.....The appropriate conceptual framework is *value at risk* - a model-driven estimate of the maximum risk for a particular balance sheet situation over a specified horizon. There are genuine issues of modeling, but there is no issue whatsoever in recognizing that this approach is the right one. If authorities everywhere enforced a culture of risk-oriented evaluation of balance sheets, extreme situations such as those of Asia would just disappear or, at the worst, become a rare species." Similarly, the Financial Stability Forum Report on Capital Flows in 2000 proposes detailed monitoring of capital flows and debt by sector, including the corporate sector.

The problem to be solved is to develop a quantitative processes to measure risk, risk shifting and changes in the value (of assets, equity and debt) of the interlinked entities or groups of entities, sectors, of an economy to produce useful, concrete and tangible results for risk analysis, risk management of a portfolio, surveillance and policy analysis.

The fields of macroeconomics and finance/risk management operate from very different base assumptions and use different languages. Macroeconomics, being based primarily on a *flow* framework, is not well suited for explicit evaluation of *risk* - risk transmission, probabilities, asset & default correlations, credit risk, or bankruptcy. However, risk managers in financial institutions have developed sophisticated tools to evaluate risk in positions on balance sheets of business units using portfolio and options techniques to evaluate expected probabilities, default risk and value at risk.

A risk manager would have great difficulty doing risk analysis of a financial institution if he or she relied only on statements of income and cash flows, without balance sheets or information on the firm's derivative positions. Risk analysis of an economy that relies on macroeconomic flow-based approach is hindered in a similar way. Explicit derivative and

option formulas are known in the art. However, implicit options have not been used to analyze risk and risk shifting or value changes among groups of entities or sectors in an economy. Effective risk analysis of an economy can be greatly enhanced by using balance sheets, containing stochastic assets with associated default barriers, and implicit options.

SUMMARY OF THE INVENTION

The present invention overcomes the disadvantages of known economic techniques, as described above, and achieves additional advantages, by providing for a method for performing a macro financial risk analysis of sectors or entities in an economy.

According to a first embodiment, the method can include the steps of: a method executed by a computer with readable memory under the control of a program, said method comprising the steps of: storing financial and economic data and parameters; calculating a value of interlinked aggregate derivatives for at least one preselected economic entities to generate a characterization of an economic value associated with at least one of an implicit economic right, to exchange a portion of said assets or portion of said debt, or an implicit economic obligation, to exchange a portion of said assets or portion of said debt, in a specific time period; and, generating an output representing said economic value.

According to a second embodiment of the invention, the method can include the steps of: a method executed by a computer with readable memory under the control of a program, said method comprising the steps of: storing financial and economic data for one or more economic entities, financial institutions, governments, monetary authorities, each entity having a plurality of associated assets; calculating value of assets and a probability distribution of assets of the one or more economic entities; calculating a default barrier value for each entities; subtracting the default barrier value from a value of said assets; calculating a distance to default at a time horizon, and an expected probability of said assets being equal to or less that said default barrier at said time horizon, so as to measure risk associated with default or events occurring when said assets are less than or equal to said default barriers; and, generating a report and graph associated with said calculations.

The present invention describes how certain risk management tools can be adapted to assess value changes and risk in economies which can be an important supplement to macroeconomic analysis. In order to avoid confusion a new term has been coined to describe this new risk management type approach - Macro Financial Risk (MFR) framework.

The present invention advantageously overcomes the deficiencies of known prior economic analysis techniques, and is superior in several respects: (i) macroeconomic variables, such as exchange rates and interest rates as well as capital flows are linked to credit risk of firms, financial institutions, government and monetary authorities; (ii) the transmission of value changes and transmission of risk of default between entities or sectors is accounted for; (iii) warning of sudden systemic crises where there is a potential for a chain reaction of defaults and transmission of default risk between sectors can be evaluated before such crises occur; (iv) differences in the effectiveness of certain policies (insolvency system or financial sector regulation) can be accounted for in this analytical framework of risk transmission; (v) the affects on risk and risk transmission of certain policy actions by the government or monetary authorities can be quantified.

The invention achieves several addition advantages over known prior economic analysis techniques: (i) it allows for the calculation of correlation between equity, loan or bond value changes and correlation of defaults across sectors and asset classes; (ii) it quantifies the rate of change of values and risk in response to certain macroeconomic variables such as exchange rates and capital flows; (iii) it allows for the calculation of the distance to devaluation and probability of devaluation.

One major feature of the invention are interlinked aggregate derivatives, that are implicit economic rights or implicit economic obligations of various entities or groups of entities in the economy. The value of these implicit economics rights and implicit economic obligations can be calculated using the invention.

Another major insight of this invention is that the entities in a sector, or entire sectors of an economy (corporate sectors, financial sectors and government, and monetary authorities) can be viewed as a portfolio of assets and associated default barriers— i.e. debt related "strike prices." Changing market prices and capital flows affect the values of assets, debt, and their associated implicit options. These affect the distance between asset values and default barriers which in turn affect credit premiums and expected default probabilities. By modeling entities and sectors in an economy in this way a new type of economy-wide risk analysis can be performed.

Macro Financial Risk framework is an economy-wide risk management approach to evaluate value changes, market risk, credit risk, funding liquidity risk, correlations (value and default correlations) and crises in an economy and for positions and investments in an economy. The invention is a quantitative method consisting of several processes called macro financial risk analysis, interlinked aggregate derivatives/options (IAD), policy effectiveness parameters (PEPs) to measure how the changes in the financial position of the major interlinked sectors of an economy affect the value (assets, equity and liabilities) and risk for an individual entity or group of entities (firms, financial institutions, central bank, monetary authorities, etc.) that produces useful, tangible and concrete results for investors, regulators and policy analysts. The framework has numerous applications for portfolio risk management, stress/scenario testing, vulnerability analysis, hedging & investment strategies, and policy.

BRIEF DESCRIPTION OF THE DRAWINGS

The features and advantages of the present invention can be understood more fully by reading the following Detailed Description of exemplary embodiments of the invention, along with the accompanying drawings, in which:
FIG. 1 is a block diagram of a computer system suitable for implementing the present invention;
FIG. 2A and FIG. 2B are a flow chart describing a method according to one embodiment of the present invention; and
FIG. 3 is a graphical representation of economic relationships useful in the embodiment of FIG. 2A and 2B.

DETAILED DESCRIPTION

For purposes of the following description of exemplary embodiments of the present invention, the following definitions are relevant.

For the purposes of this invention, terms not specifically defined below are defined in the book "Financial Programming and Policy," by the IMF Institute, 2000, or in "Options Futures and Other Derivatives," by John Hull, fourth edition 2000.

"Economic entity" is a firm, corporation, financial institution, bank, financial intermediary, insurance company, financial-industrial group, central bank, government, household, monetary authority, or international financial institution. Economic entities are more than one economic entity. A "sector" is defined a one or more legal persons or economic entities.

"Asset" is defined as property and resources of a business, economic entity, person that have a cash value and can be used to pay the debts of the economic entity. "Expected asset value" is the mean asset value at a time in the future and the distribution of an asset is the probability that an asset will be a certain value at a certain point in the future as is known in the art. "Alternative asset value" is another value of the assets and another value of the distribution of asset values to be used to calculate the value of exchanging the alternative asset for the first asset, debt or alternative debt value. "Debt" is an explicit obligation of one economic entity to pay or pay back another economic entity. "Alternative debt value" is another value of the debt to be used to calculate the value of exchanging this alternative debt for an asset, alternative asset or debt.

The "debt of economic entities" is broken down into structure and maturity of debt owed (long term, short term, domestic currency, and foreign debt) and shares of debt owed to financial institutions by economic entities. The debt of financial institutions of the monetary authorities includes debt and deposits. The assets, liabilities and debt of economic entities or other macroeconomic aggregates are defined in "Financial Programming and Policy," by the IMF Institute, 2000.

"Macro Financial Risk (MFR)" analysis is the analysis of economic value changes, risk and risk transmission for economic entities, groups of economic entities, or sectors in an economy that uses the values of IADs (see definition below) and uses measures of credit risk, devaluation risk and value changes derived from analysis of the relation of assets to default barriers for said entities, groups of entities and sector. MFR is an embodiment of this invention.

"Macroeconomic parameters" include macroeconomic variables such as exchange rate, interest rate in the country, interest rate outside the country, government net fiscal revenues, gross domestic product of the economy, etc. These parameters include macroeconomic indicators, macroeconomic aggregates, and prices that are defined or used in the book Financial Programming and Policy by the IMF Institute, 2000.

An "option" is a subset of a derivative. A "derivative" which is an instrument or product whose value is derived from another instrument asset or prices. The "delta of an option" is

the change in option value relative to the underlying asset and the "gamma of an option" is the change in the delta relative to the underlying asset.

"Macro financial risk parameters" are parameters or factors for an economic entity or group of entities or sector including: the share of near term debt payable before time t for an economic entity or group of entities or sector, long term debt factor (see definition of default barrier), policy effectiveness parameters or PEPs (see definition of PEPs), risk free discount rate, sovereign risk premium (i.e. interest rate spread on sovereign debt reflecting sovereign risk), standard deviations of probability distributions of assets or combined assets, recovery rates after default, asset correlation parameters for two or more assets, and tail factor to increase the size of the tail of a normal or lognormal probability distribution.

"Interlinked Aggregate Derivatives (IADs)" is a mathematical algorithm to calculate the economic value associated with at least one of an implicit economic right, to exchange a portion of said assets or portion of said debt, or an implicit economic obligation, to exchange a portions of said assets or portion of said debt, in a specific time period. The mathematical algorithm can be one based on options or derivatives valuation formulas such a the formulas are commonly used for individual explicit derivatives know in the art such as formulas used to calculate the price of a derivative or option, such as the Black-Scholes formula, American option pricing formulas, binomial tree calculation approaches, trinomial tree calculation approaches. One entity, group of entities or sector is "long," i.e. has the implicit right to have or buy an asset, instrument, debt or payment upon an event, and the other counterparty entity, group of entities or sector is "short," i.e. has the implicit obligation to buy or make payment related to an asset, debt, instrument or payment upon the occurrence of the event. The IADs represent implicit contingent claims or implicit contingent exchanges of an instrument, debt, asset or payment that is derived from some event that can happen. The IAD formulas, in this definition, include policy effectiveness parameters (PEPs) via their estimated impact on reduction/increase the value of interlinked aggregate derivatives/options.

"Interlinked aggregate derivative asset exchange option" is a subtype of IAD, the type wherein assets of an economic entity are exchanged for another asset. These include IAD fiscal revenue exchange options or IAD monetary authority exchange options among other types. "Interlinked aggregate derivative near term debt exchange option" is a subtype of IAD based on the expected debt payable values and the designated portion of near term debt exchanged for longer term debt. "Interlinked aggregate derivative put option" is a subtype of IAD whereby a portion of assets, and debt obligations, of an economic entity and a portion of the debt obligations of the is transferred to another economic entity.

"Interlinked aggregate derivative financial sector put option" is a subtype of IAD whereby a portion of the assets, and portion of the debt and deposit liabilities, of a financial institution are transferred to another economic entity, usually the government and monetary authority. As part of this invention the IAD financial sector put option has embedded in it the portfolio, or group, of IAD put options from firms that have loans to the said financial institution. The value of the IAD financial sector put option represents an implicit economic benefit to said financial institutions or groups of financial institutions but is an implicit cost to the governments and monetary authorities. "Interlinked aggregate derivative call option" is a

subtype of IAD that measures the economic value to exchange assets minus debt for a group of firms or financial institutions.

"Interlinked aggregate derivative credit event (CEP)" is a subtype of IAD payment is the implicit economic value of an implicit payment which is paid to one economic entity that is the implicit obligation of and paid by another economic entity.

"Policy effectiveness parameters (PEPs)" are a factor that varies from 0 to 1 that is multiplied by the underlying asset value or debt value or default point value in an IAD algorithm. The represent and incomplete exchange or payment and thus affect the economic value of interlinked aggregate derivatives. One type of PEP is the PEP on the effectiveness of the insolvency system in a country wherein the PEP is the designated minimum share of assets transferred to holders of debt in the event that debt payable in the near term before time t is not or cannot be paid by firms or groups of firms.

"Time period" is a time interval, this definition includes "time horizon" which is the time interval from one point in time to a point in the future for calculating the various values or to use in formulas. Both the time period and time horizon are variable.

"Distance to default (DtoD)" is the expected value of assets at the time horizon minus the default barrier at said time horizon divided by the standard deviation of the asset value of the economic entity, group of economic entities or sector. It measures the risk associated with default or events occurring when said assets are less than or equal to said default barriers. It is the number of standard deviations of asset value that the mean asset level is away from the default barrier at a specific time. The probability of default is measured by the proportion of the probability distribution that is less than the default barrier.

"Default barrier" is defined in this invention to be the near term debt payable plus (the long term debt factor times the long term debt payable). When assets are equal to or less than the default point the entity is in default on its debt obligations. Default barrier is variable wherein the default barrier varies according to one or more of the following factors: exchange rates, interest rates in the country, interest rates in other countries, the share of near term debt exchanged for long term debt, and other factors.

The "combined asset value" for an economic entity is found by adding assets to interlinked aggregate derivatives of the entity that have the characteristics of an asset. The "combined value of variable default barrier" is found by adding the default barrier of the entity to the interlinked aggregate derivatives of the entity that have the characteristics of debt or liabilities.

A "devaluation" is a change in the exchange rate, i.e. the rate at which the monetary authorities exchange local currency for foreign currency. "Distance to devaluation," for the monetary authorities, is the assets of the monetary authorities minus the point, equal to a factor multiplied by the default barrier of the monetary authorities, and divided by the standard deviation of the asset value of the monetary authorities. If the assets of the monetary authorities are equal to or below such said point a devaluation of the exchange rate occurs

"Credit risk" is the risk and economic entity will default on debt obligations.

"Aggregation" is any common method of aggregation of financial data known in the art such as average of key financial components of entities in a group, financial data of proxy firms/entities that are representative of a larger number of entities.

"Risk adjusted discount rate" is a discount rate used to discount cash flows of a risky asset or liability of an entity, such as the asset value of a corporation that discounts free cash flow. This risk adjusted discount rate includes a risk free rate (US), sovereign spread, and betas or measure of the ratio of the volatility of the equity market in one country relative to another, such as the US.

"Policy analysis" is analysis of the impact of most any economic or financial policy, macroeconomic, legal, regulatory, structural, aggregate swaps, restrictions, exchange rate regime and policy action, monetary policy procedure, etc.

The MFR approach used in the exemplary embodiments described below has several new features not obvious to the those familiar with economics and finance, including:

- First, there are different types of implicit aggregate derivatives, including implicit options, between entities and between groups of entities in sectors of an economy. Two types are implicit exchange options or implicit credit event payments. Implicit exchange options are options to exchange various assets and debt. Implicit credit event payments are similar to what might be called implicit credit default swaps, but with implicit payments on certain credit events.

- Second, an important insight of the MFR approach is that one economic entity or group or sector is "long" and another sector is "short" each aggregate implicit option. Likewise the loans, investments and positions of foreign lenders and investors are short or long various embedded IADs.

- Third, there are many types of IADs. Some implicit options are exercised at default and others prior to default in order to prevent or forestall default. Changes in exchange rates affect the central bank balance sheet directly and indirectly via the implicit compound options. Some IADs are compound options, i.e. implicit options embedded in other implicit options.

- Fourth, the MFR approach incorporates macro links, including capital flows, liquidity, and exchange rates and other prices. These affect the variability of the default barrier of entities and, in some cases, whole sectors. The framework incorporates IAD near tem debt exchange options that may be specific to a liquidity context (or lender of last resort/moral hazard context).

- Fifth, the increased risk of certain ineffective policies in the country can be captured through parameters built into the option formulas. The effectiveness of the insolvency system affects the share assets that are transferred to creditors in default and recovery rates. Some important aspects of the effectiveness of financial sector regulation and

supervision can be included in the option pricing formulas. The effectiveness of tax collection is in the IAD fiscal exchange option.

- Sixth, the MFR approach measures deltas (slope), gammas (convexity), and relate of change of IADs. This helps evaluate vulnerability, crisis points, and to quantitatively estimate the impact of possible hedging or vulnerability reduction measures.

The MFR framework in the exemplary embodiments thus applies an economy-wide risk management approach to key, preselected entities and sectors.

There are numerous advantages of the MFR approach. Values of the IADs, together with the on-balance sheet aggregates, are interlinked and affected by changes in capital flows and market variables ---such as exchange rates, domestic interest rates, foreign interest rates, commodity prices, etc. Interlinked credit risk is incorporated automatically links with market prices and capital flow related liquidity or loan rollover risk. Even without specific default events, the changing values of these options are useful measures of credit premiums and probability adjusted measures of value inherent in the particular structure of assets, debt and underlying legal and regulatory framework of an economy.

The most general form of IAD is an implicit exchange option. Implicit puts, implicit calls and many other implicit options are subsets of implicit exchange options as such options involve exchanges of securities with each other, with cash or exchanges of cash flows. An implicit exchange option can be seen as the implicit option to choose the maximum of two assets, U_T and V_T, max (U_T, V_T) or minimum the two assets, min (U_T, V_T). The better or worse of two assets can be regarded as a position in one of the assets combined with and option to exchange it for the other asset. The max (U_T, V_T) = U_T + max (V_T - U_T, 0), which means long the asset U_T with the right to exchange it for V_T. The max (V_T - U_T, 0) is a long call option on V_T with a strike price of U_T. The min (V_T, U_T) = U_T - max (U_T - V_T, 0), which means long U_T plus a short call option. The summary of IADs of the type implicit exchange, put and options are given below.

Implicit Exchange option	max (U_T, V_T) = U_T + max (V_T - U_T, 0)
Implicit Exchange option	min (V_T, U_T) = U_T - max (U_T - V_T, 0)
Implicit Long call option	+ max (V_T - U_T, 0)
Implicit Short call option	- max (V_T - U_T, 0)
Implicit Long put option	+ max (U_T - V_T , 0) = - min (V_T - U_T, 0)
Implicit Short put option	- max (U_T - V_T , 0) = min (V_T - U_T, 0)

Implicit put options and implicit call options, and their relationship, can be derived from the exchange option formulas. The max (U_T, V_T) = max (V_T, U_T) is the equivalence of exchanging U_T for V_T or V_T for U_T, thus max (V_T - U_T, 0) = V_T - U_T + max (U_T - V_T, 0).

If an economic entity has or in principle can have traded equity and equity holders that can actually claim (or "call") assets and can "put" assets to satisfy debt obligations then the implicit exchange options are:

1. An implicit exchange option of Assets – Debt, or nothing, is equivalent to a call option, and implicit exchange option of Debt – Assets or nothing, is the embedded put option associated with debt;

2. The debt includes and embedded near-term debt exchange option.

Behavior is driven by the actions of equity holders and managers to maximize value as the default barrier gets nearer. First, certain liquid assets maybe used to pay near term debt, then efforts are made to exchange as much near-term debt as possible for long term debt, and finally when assets fall to the level of the default barrier default occurs. The implicit exchange option can be seen as being embedded in the implicit call option (or implicit put option) for corporates and financial institutions:

$$\text{Implicit Call Option} = \max [A - \min [\eta\ D_{NT}, \alpha_{nt}D_{LT}\ ] - (1 - \eta\ )D_{NT} - \alpha D_{LT}\ ,\ 0]$$
$$\text{Implicit Put Option} = \max [- A + \min [\eta\ D_{NT}, \alpha_{nt}D_{LT}\ ] + (1 - \eta\ )D_{NT} + \alpha D_{LT}\ ,\ 0]$$

A = Asset Value
η = Share of near-term debt exchanged for longer term debt
D_{NT} = Near-term debt
α = factor multiplied times long-term debt as part of default barrier
${}_{nt}D_{LT}$ = Long-term debt for which the near-term debt is exchanged, it may be equal, lower or higher than ηD_{NT} depending on refinancing terms for interest rate i, ${}_{nt}D_{LT}=\eta D_{NT}\, e^{it}$

If an entity, such as a government or central bank, does not have equity holders that can actually claim assets and can put assets to satisfy debt obligations then the implicit exchange options are:

1. An IAD *asset exchange option;*

2. A IAD *near term debt exchange option.*

Behavior of managers of these "public" entities is modeled as being determined by actions to avoid assets reaching a certain barrier, which is equivalent to taking actions to avoid net worth, i.e. assets minus debt, falling to or below zero. The type of barrier is determined by the nature of the public entity. The barrier for the is government barrier where its sovereign debt is in default and it becomes a necessity to engage in debt restructuring negotiations with creditors, which is sometimes a protracted and costly process. For a central bank, as assets approach a "default" barrier a devaluation is most likely the reaction so as to raise the local currency value of foreign assets. There is thus a devaluation barrier which is equal to or somewhat greater than the default barrier.

For governments, central banks, and other entities there are really no contingent rights to claim assets or put assets there is no real legal or traded equity. However, these entities do have the implicit options to exchange current assets for another asset, and exchange short term debt for longer term debt. So the value of net worth is: Net worth = Assets minus Default Barrier > 0. Net worth thus equals maximum of choosing asset 1, A_1, or asset 2, A_2, minus the minimum of current debt barrier or new debt barrier with part of near term debt rolled over or restructured must be greater than zero (or some fixed level), this give the following IADs:

$$\max [A_1, A_2] - \min [\eta \ D_{NT}, \alpha_{nt} D_{LT}] - (1 - \eta) D_{NT} - \alpha D_{LT} > 0$$

$$A_1 + \max [A_2 - A_1, 0] - \min [\eta \ D_{NT}, \alpha_{nt} D_{LT}] - (1 - \eta) D_{NT} - \alpha D_{LT} > 0$$

An embodiment of the invention permits a number of implicit options in the operations of economic entities in an economy. All the economic entities that have debt have implicit near term debt exchange options, i.e. the option to exchange near term debt for log term debt. Some entities have equity, i.e. ownership stakes that can be bought or sold. If entities have equity they also have two types of implicit exchange options, implicit call option and implicit put option, in addition to the implicit near term debt exchange option. If the economic entities are public, such as governments or monetary authorities, they have implicit options to exchange assets as well as the implicit near term debt exchange option. In any economic entity the portion of assets or debt that can be exchanged can vary from zero to one hundred percent. The portion of exchanged assets or debt is determined by parameters in the IAD formulas and they influence the level of the default barrier and assets. Some of these parameters are influenced by the liquidity and capital flows in the economy which affects the amount of near term debt that can be exchanged for long term debt. Some other of these parameters are the policy effectiveness parameters reflecting the effectiveness of the legal and regulatory framework. An example of the policy effectiveness parameters in the formulas are the effectiveness of the legal system in forcing economic entities to transfer a minimum portion of assets to the creditor in case of default or bankruptcy. Another example is the maximum portion of debt and deposits of financial institutions that the governments will take over in case of insolvency of the financial institution. Another example is the proportion of additional net government revenues that can be effectively be collected by the tax administration authorities. Another example is the maximum amount of "liquidity support," or revenue transferred, to distressed financial institutions by the monetary authorities.

The invention relates generally to the processing of financial and economic data. More particularly, this invention relates to a technique for modeling risk between entities and sectors in an economy. In the exemplary embodiments of the present invention to be described below,

FIG.1 illustrates a general purpose computer 20 suitable for carrying out the methods of the present invention includes a central processing unit (CPU) 22, which communicates with a set of input/output devices 24 over a bus 26. The I/O devices 24 may include a keyboard, mouse, video monitor, printer, etc. The CPU 22 also communicates with elements containing memory 29 through 39 over the bus 26. The interaction between a CPU 22, I/O devices 24, and a bus 26, and a memory are all well known in the art; the present invention

is directed toward the operation of these elements with respect to a set of programs stored in memory 29 through 39.
Memory 29 through 30, stores financial data on entities, groups of entities & sectors 29, stores macroeconomic and parameter data 30. This is transferred to the preprocessor 31. The next steps are to use mathematical algorithms are used to calculate IADs and DtoDs for firm, groups of firms, or firm sectors labeled "Ci" where "i" is the number of the firm, groups of firms, or firm sectors 32. The next step is to use the output of 32 together with previously stored data to calculate IADs and DtoDs for financial institution entities, groups or sectors labeled "Fj" where "j" is the number of the financial institution entities, groups or sectors 33. The next step is to use the output of 33 together with previously stored data calculate IADs and DtoDs for government 34.
The next step is to use the output of 34 together with previously stored data calculate IADs and DtoDs for monetary authorities and other entities 35. The next step is to readjust parameters for scenario analysis 36. The next step is to calculate IAD call option values (equity) and debt values minus the IAD put option values for each economic entity and calculate value and correlation matrix 37. This value and correlation matrix is used with stored data on risk management positions & portfolio 38 to calculate covaried portfolio value. The next step is to generate reports, graphs and other output 39.

The foregoing discussion provides a general overview of the elements of process and apparatus of an embodiment of the invention. Attention is presently turned to a more detailed discussion of selected embodiments of the invention. A method executed by a computer under the control of a program includes the steps of storing financial and economic data in the computer. FIG.2A and FIG. 2B shows the numbered steps.

Data is stored on equity market value, assets and debt, alternative asset values, alternative debt values, alternative equity values, for entities or sectors for corporates Ci, for financial institutions Fj, and assets and debt for government and monetary authorities 40. Data is stored data on exchange rate, near term debt exchange factors, far term debt discount factors, PEP parameters, risk free discount rate, time period, time horizon, and risk management positions 42. Module 1 calculates asset values and distributions for Ci 44. Module 2 calculates default barriers for Ci 46. For Each Ci the value of long term debt plus the share of short term debt exchanged for long term debt are added together and multiplied by the long term debt discount factor and added to the value of short term debt; to this is added the value of the exchange rate multiplied by the total of long term foreign currency debt plus the share of short term foreign currency debt exchanged for long term foreign currency debt added together and multiplied by the long term debt discount factor and added to the value of short term foreign debt. These debt and foreign debt figures comprise the default barrier and are also inputted in Module 3. For Ci the asset value, the standard deviation of assets, from Module 1, time period, are inputted into Module 3. The PEP parameter for the effectiveness of the insolvency system is retrieved from the memory 42 and also inputted in Module 3. Module 3 calculates, using an algorithm, the IAD call option, IAD put option, assets minus default barrier, DtoD for each Ci 48 and stores the data for use as input into other modules and for later printing, graphs or output.

Module 4 calculates asset values and distribution for Fj including IAD put options from module 3 50. The value of non-loan assets for each Fj is added to loans outstanding from Fj

to each Ci is retrieved from memory 40 and from these loan values is subtracted the value equal to the IAD put option, from 48, for each Ci, multiplied by the fraction of loans outstanding from Fj to Ci. For each Fj the asset value, the standard deviation of assets, time period, a inputted into Module 4. Module 5 calculates default barriers for Fj 52. For each Fj the value of long term debt plus the share of short term debt and deposits exchanged for long term debt and deposits are added together and multiplied by the long term debt discount factor for Fj and added to the value of short term debt; to this is added the value of the exchange rate multiplied by the total of long term foreign currency debt and deposits plus the share of short term foreign currency debt and deposits exchanged for long term foreign currency debt and deposits, added together and multiplied by the long term debt discount factor for Fj and added to the value of short term foreign debt and deposits. These debt, deposit, foreign debt, and deposit figures comprise the default barrier of Module 5 and are used in Module 6 as inputs. The PEP parameter for the effectiveness of the financial system regulation system is retrieved from the memory 42 and also inputted in Module 6. Module 6 calculates, using an algorithm, the IAD call option, IAD put option, assets minus default barrier, DtoD for each Fj 54 and stores the data for use as input into other modules and for later printing, graphs or output.

Module 7 calculate asset values and distribution for government including IAD fiscal options from 56. Module 8 calculate of default barriers for government including IAD financial sector put option from module 6, 58. Module 9 calculate distance to default and asset minus default barrier for government 60.

Referring to FIG 2B, continuing from FIG. 2A, Module 10 calculate asset values for monetary authorities including asset exchange option and CEPs from international monetary fund and international financial institutions 62. Module 11 calculate default barrier for monetary authorities including liquidity CEPs, foreign currency exchange option 64. Module 12 calculate asset minus default barrier distance to devaluation for monetary authorities 66. Module 13 scenario analysis retrieves stored scenario values from memory 40 and 42, exchange rate, fiscal IAD exchange option assets, level of liquidity in liquidity CEPs, PEP in financial sector put option, asset level in exchange option, macro financial risk parameters and CEPs from international monetary fund and international financial institutions, near term debt exchange factors and recalculates steps 44 through 66 according to the stored instructions in 68. Module 14 uses input from 68 calculate value matrix for IAD call options for Ci and Fj and IAD put options plus debt face value for Ci and Fj 70. Module 15 calculates expected default probability for government and expected devaluation for monetary authorities 72.
Module 16 calculate value of government debt including expected default probability 74.
Module 17 calculates value matrix, correlation matrix for Ci IAD call options, Ci IAD loans minus IAD put options, Fj IAD call options, Fj IAD put options, government debt 76.
Module 18, using output of 76 calculates value of positions and investments in portfolio 78.
Module 19 calculate deltas and gammas of IADs according to algorithm 80. This algorithm 80 measures the rate of change of the IAD option values for an incremental change in asset values. Relevant reports and graphs are generated 82.

For each economic entity FIG. 3 illustrates the asset value probability distribution 90 and the default barrier 92 at time t_1. The distance to default 94 is the mean asset value of 90 minus the default barrier 92, divided by the standard deviation of asset value. The area to the

right of the default barrier 92 is the expected probability of default 96 and is mathematically related to the distance to default 94.

The foregoing description, for purposes of explanation, used specific nomenclature to provide a thorough under- standing of the invention. However, it will be apparent to one skilled in the art that the specific details are not required in order to practice the invention. Thus, the foregoing descriptions of specific embodiments of the present invention are presented for purposes of illustration and description. They are not intended to be exhaustive or to limit the invention to the precise forms disclosed, obviously many modifications and variations are possible in view of the above teachings. The embodiments were chosen and described in order to best explain the principles of the invention and its practical applications, to thereby enable others skilled in the art to best utilize the invention and various embodiments with various modifications as are suited to the particular use contemplated.